29th Annual INCOSE international symposium
Orlando, FL, USA
July 20 - 25, 2019

Improving the information transfer between engineering and installation: case study at AS Nymo

Erik Thygesen, AS Nymo, Norway
Gerrit Muller, University of South-Eastern Norway
Satyanarayana Kokkula, University of South-Eastern Norway

www.incose.org/symp2019

Who is presenting

Satyanarayana Kokkula (Satya)
Associate Professor in Systems Engineering
University of South-Eastern Norway

Research interests
- Testing and verification, Systems Engineering, Product development, Robust design, Crash mechanics and Numerical simulations

Work Experience as
Specialist Engineer, Structural Analysis at FMC Kongsberg Subsea AS (2006 - 2016)
Assistant Systems Engineer at TATA Consultancy Services, Pune, India (2001 - 2002)

Educational Background
PhD in Structural Engineering, NTNU (2002 - 2005)
M.Tech in Applied Mechanics, Indian Institute of Technology (IIT) Delhi, India (1999 - 2000)

Agenda

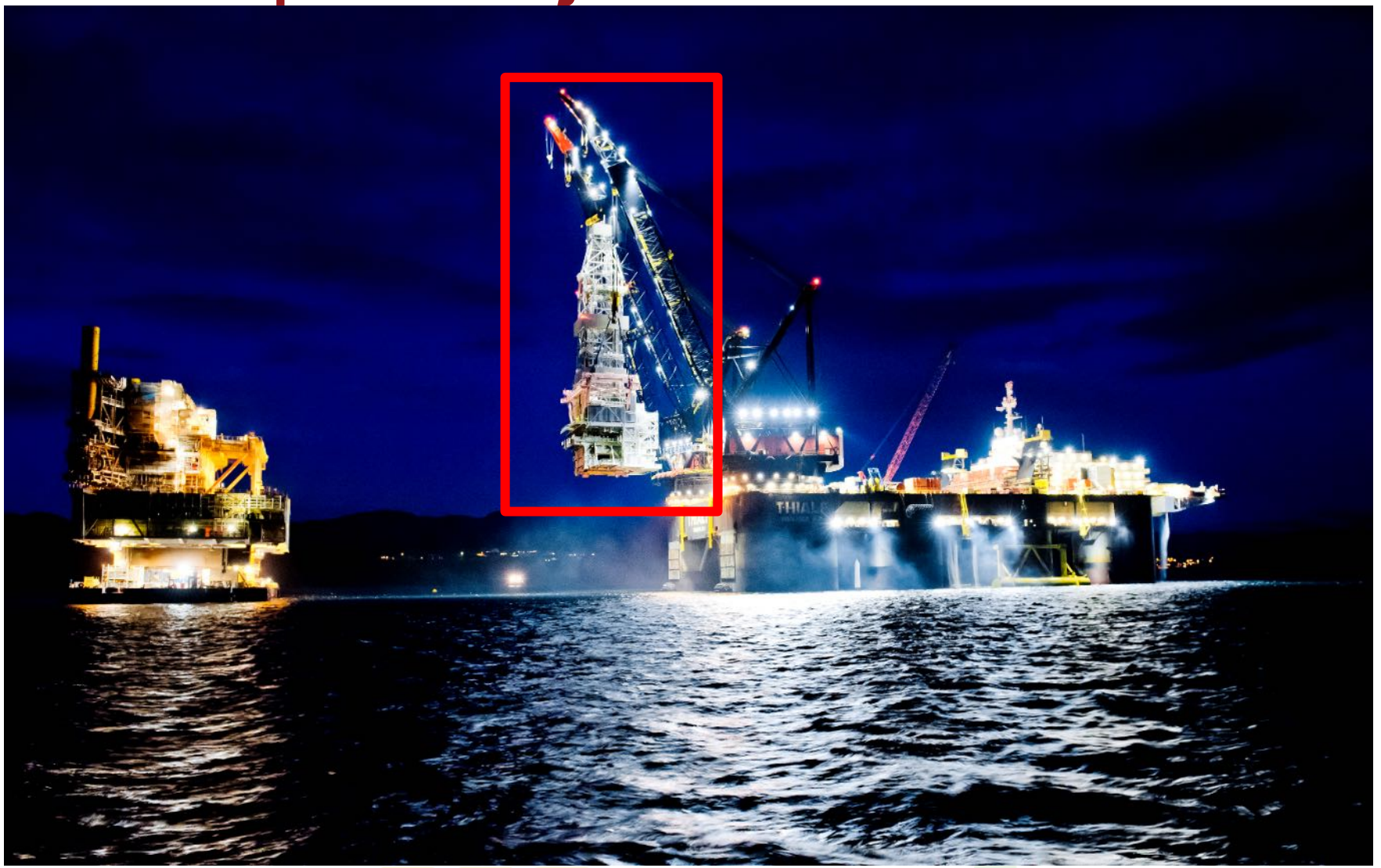
- Introduction of AS Nymo
- Research Domain
- Motivation for research
- Research questions
- Research methodology
- Research Findings
  - Understanding
  - Exploration
  - Optimization
  - Verification
- Conclusions

Case Study: AS Nymo

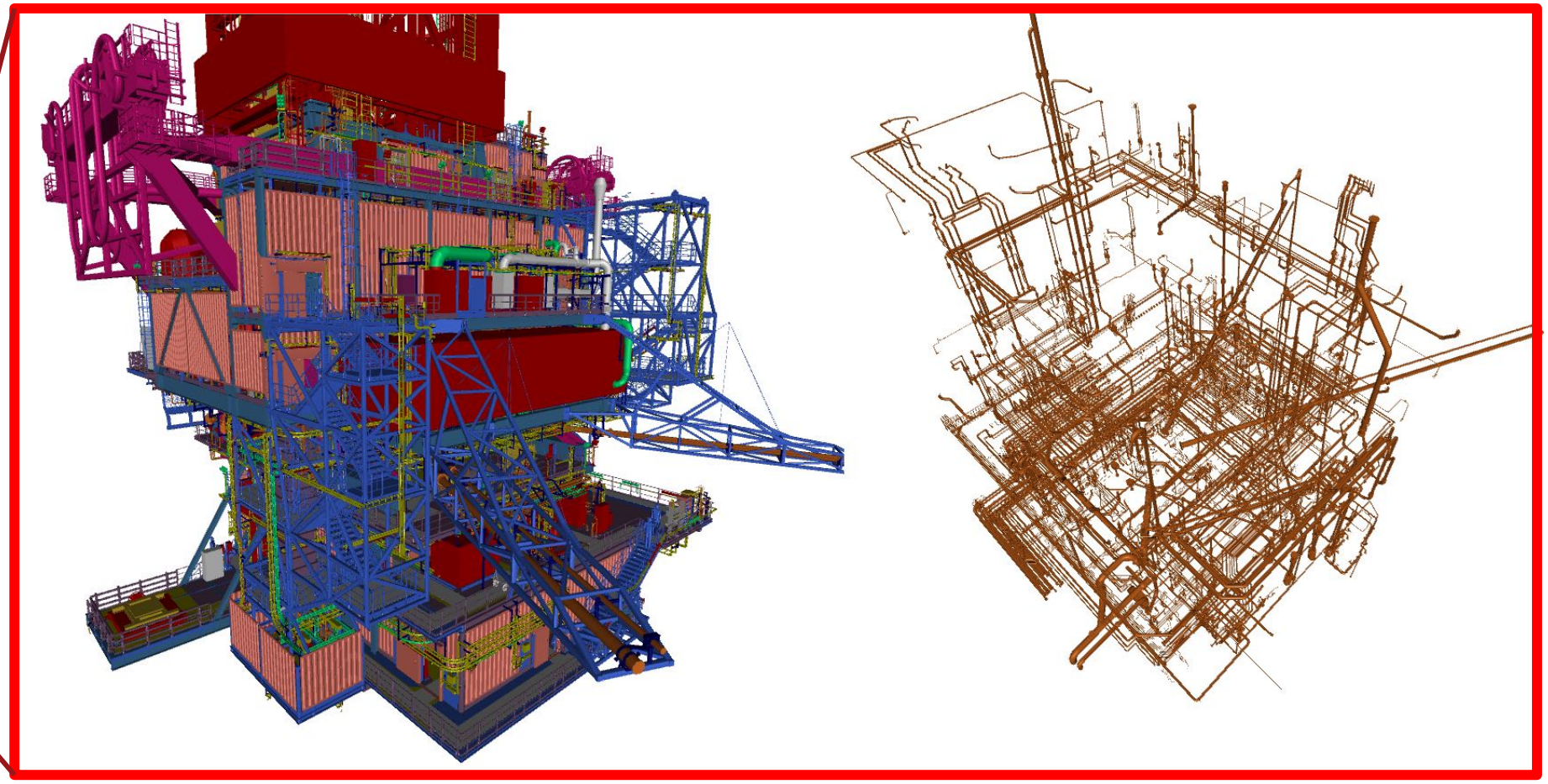
- Construction Yard with main office in Grimstad, Norway
- Just above 200 employees
- Main market: EPC of 1,000-4,000 tonnes highly complex modules for the offshore oil and gas industry

Example Project: JSDP DES

Example Project: JSDP DES



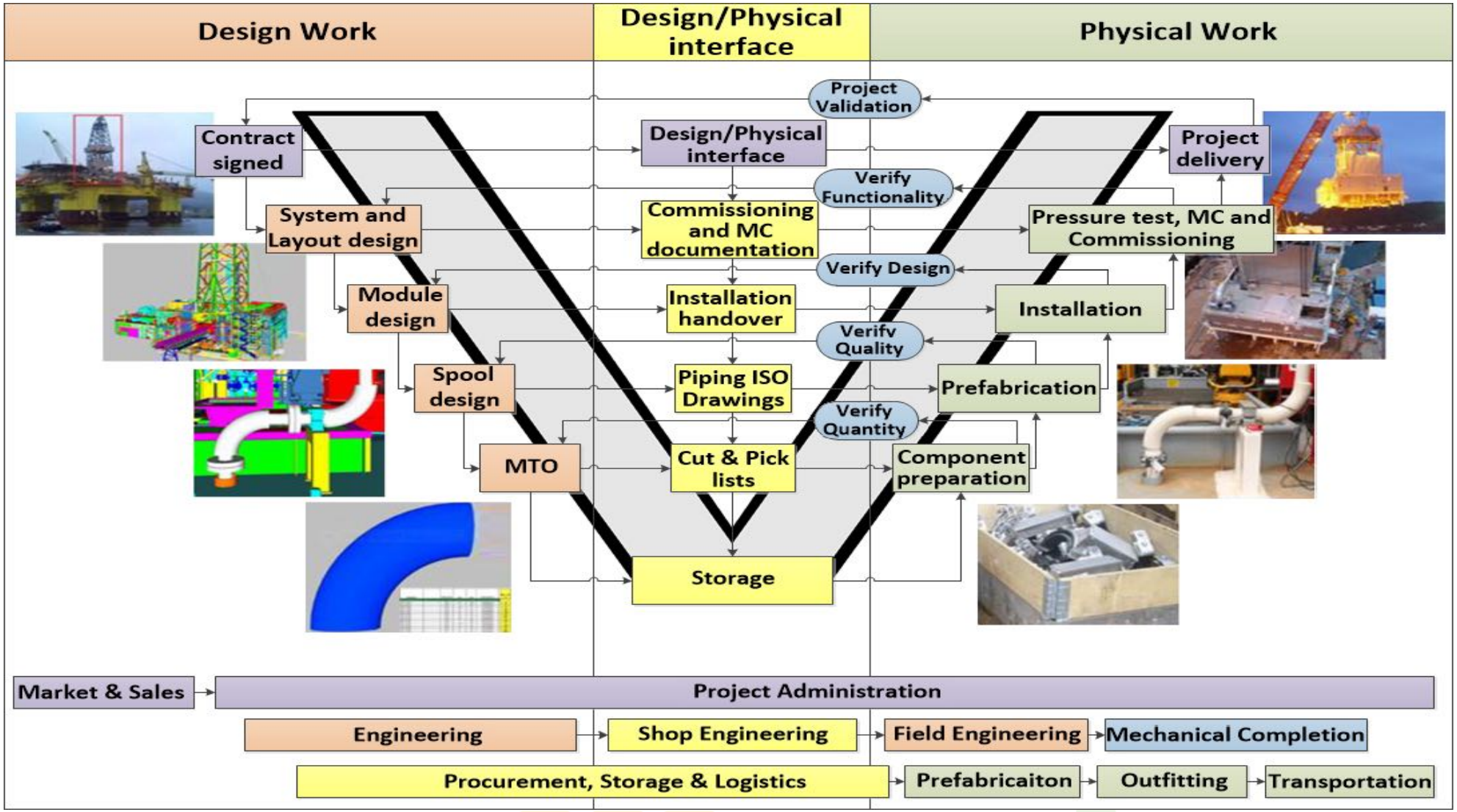
Research Domain



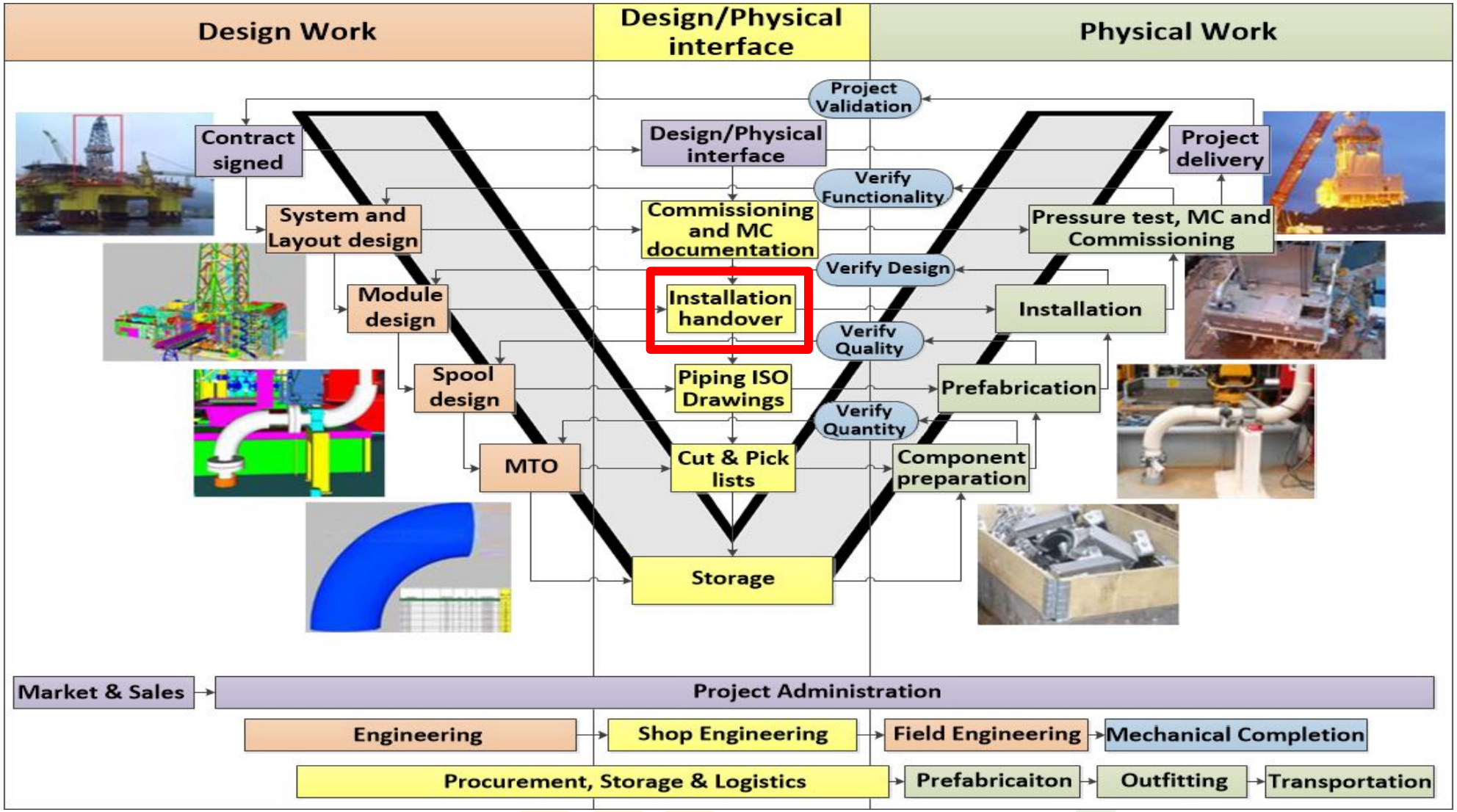
Piping Scope:

- 114 Ton
- Approx. 900 line numbers
- Approx. 23 km pipes

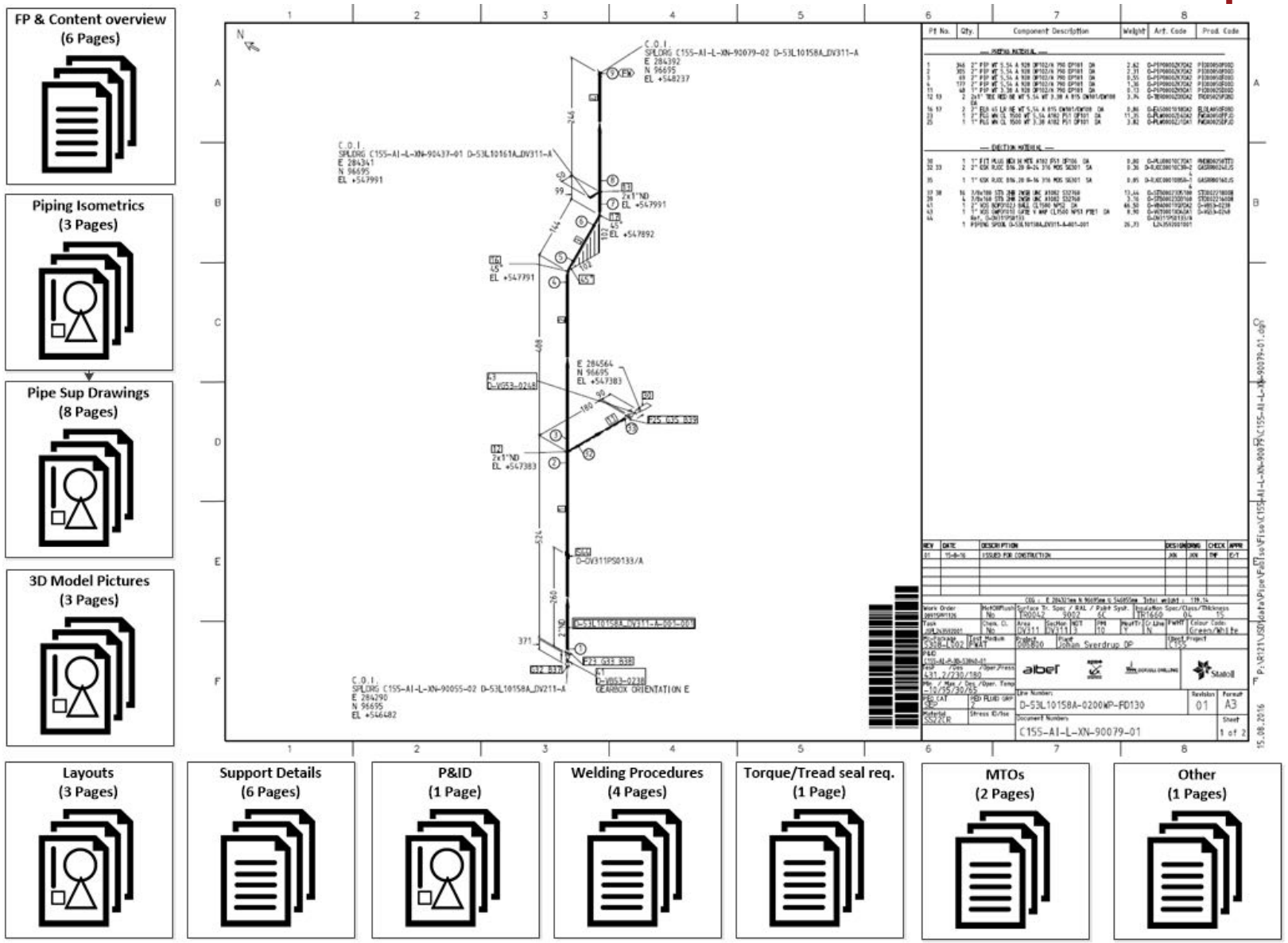
Research Domain



Research Domain



Research Domain: Example



Typical Installation Handover:

- Contains 3 Piping Isometrics
- Consists of a total of 38 pages

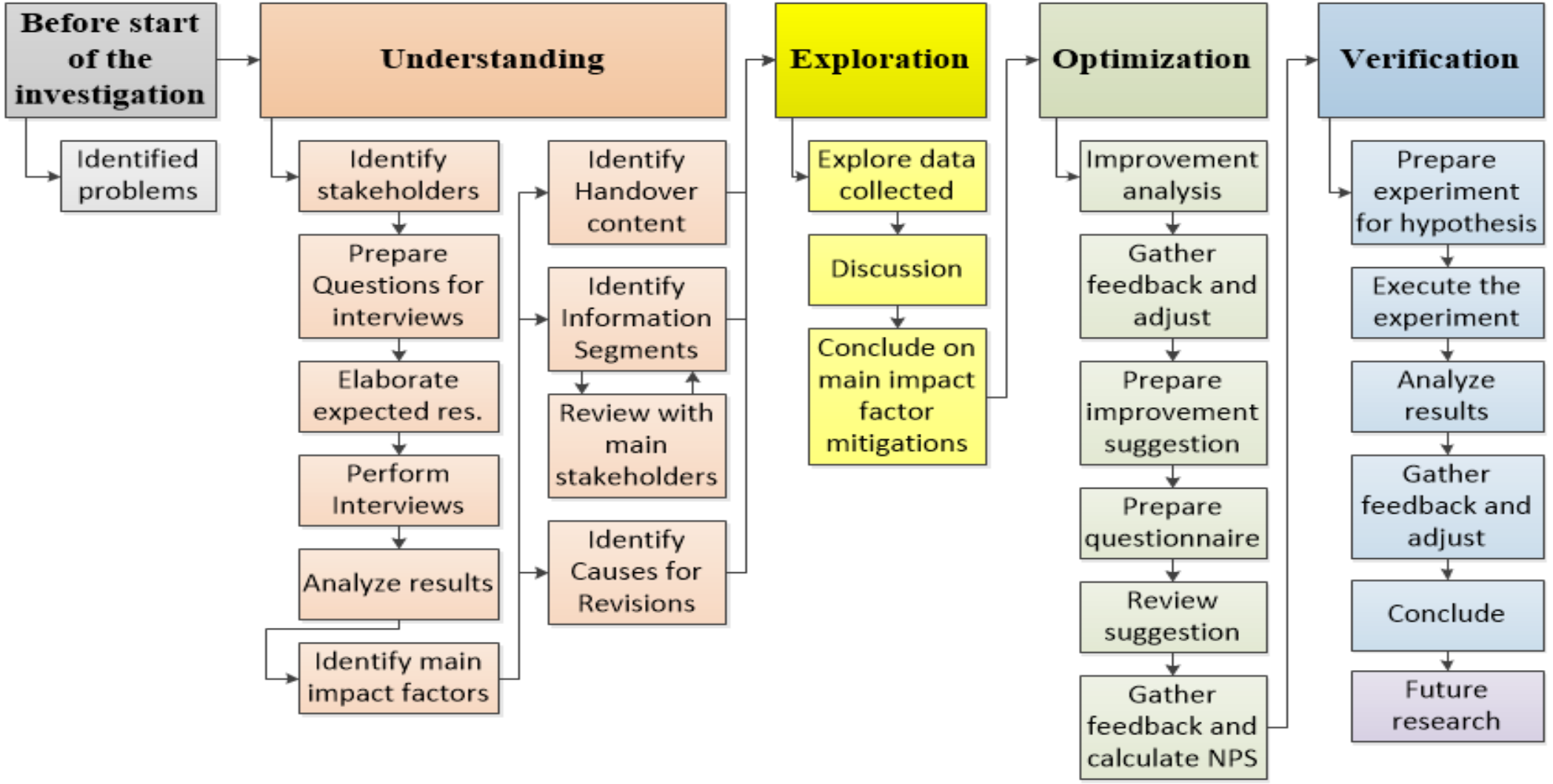
Motivation for research

- On average, more than 50% hour overrun compared to plan during piping installation on the four major projects over the past ten years
- Earlier studies indicates 31 % waste during installation
- Two studies links 11 % of this waste directly to the handover
- A potential of reducing 4,800 hours, or 3.1mill NOK during installation (other synergies not included)

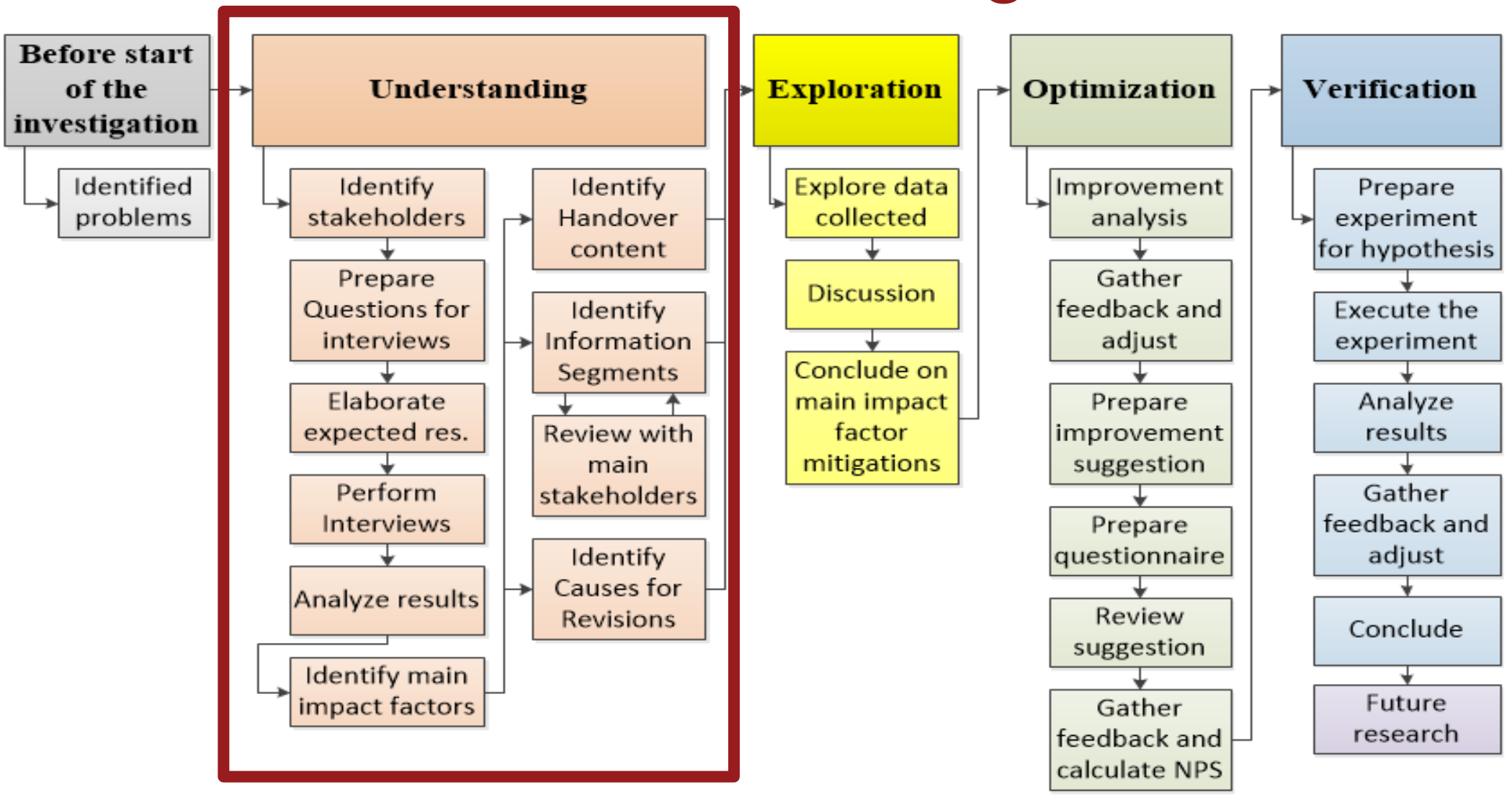
Research questions

- What are the main impact factors causing confusion and misinformation in the installation handover format?
- How can the new knowledge about the main impact factors contribute to make the handover format more correct, intuitive, and usable for the receiving stakeholders?

Research methodology



Understanding



Stakeholder analysis

Before start of the investigation (previous slide) → **Identify stakeholders**

Prepare Questions for interviews (next slide)

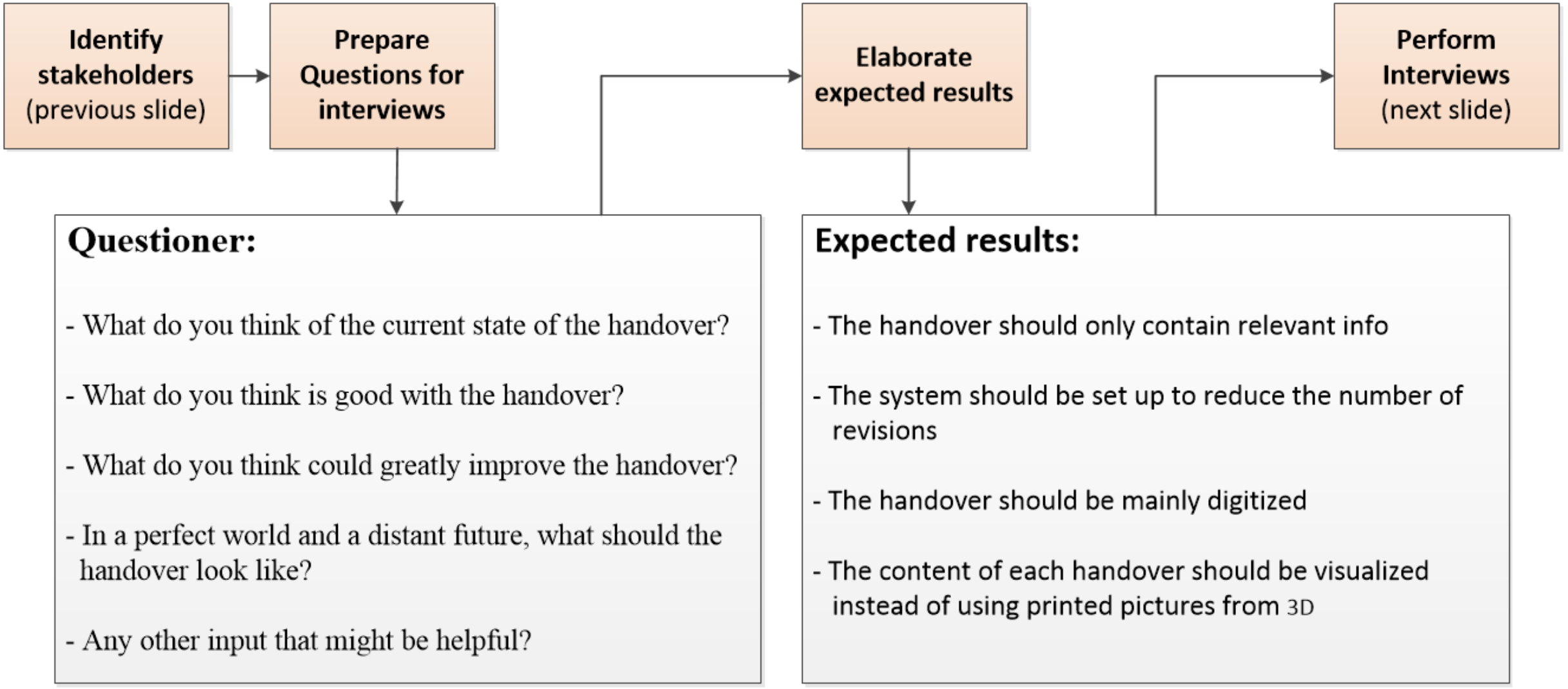
Perform stakeholder analysis

Affected by the handover

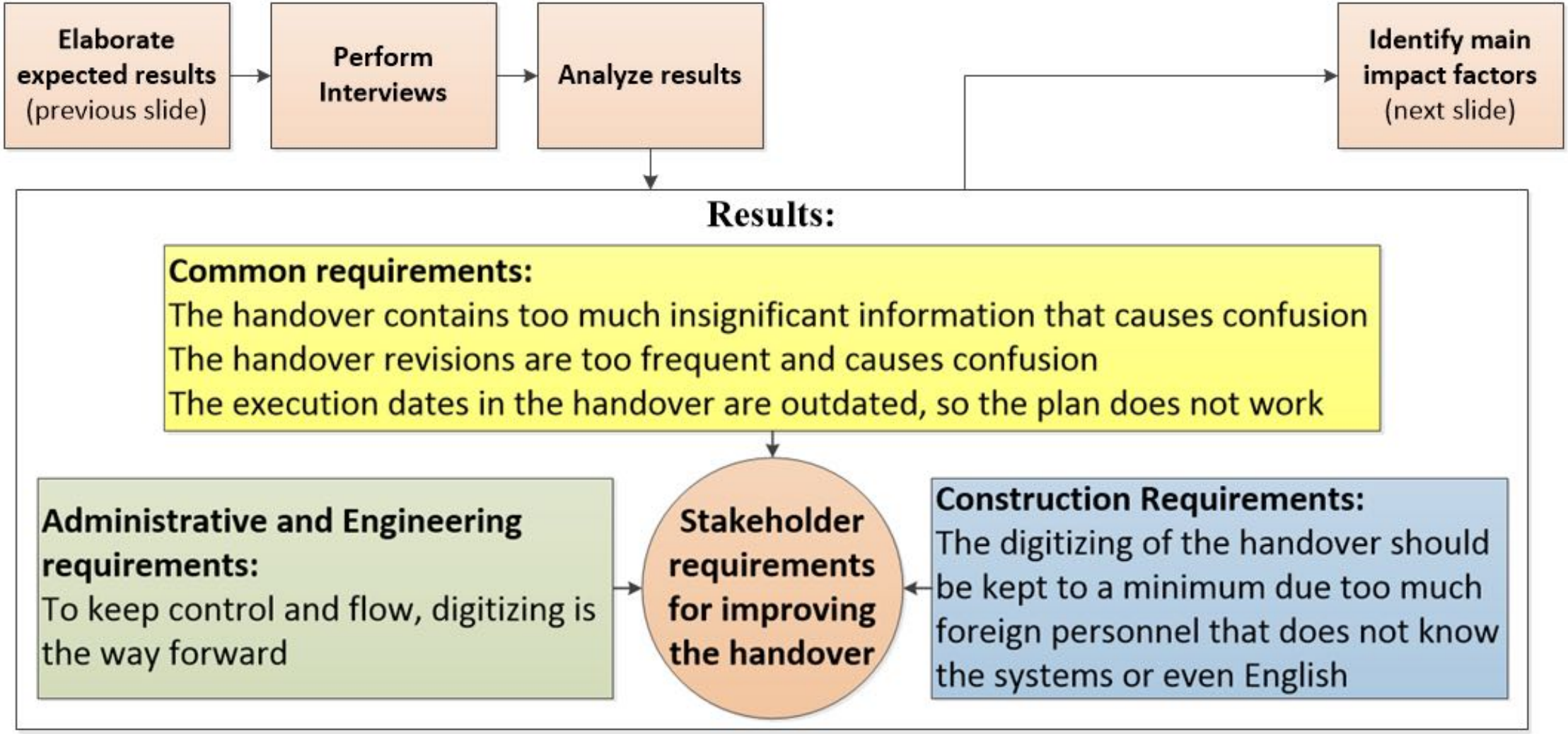
Stakeholders to be informed **General involvement to gather impression** Installation Operators Piping Engineers Shop Engineers **Interview of a selected few (approx. 10%)**	**Involved stakeholders** **Detailed involvement among all available personnel** Installation Supervisors Piping Engineer Lead Shop Engineer Lead **Interview of a all leaders and 80% of foremen**
Stakeholders to be briefed **Generally briefed when important** Project Controller Storage Responsible Logistics Responsible Prefabrication Supervisors Painting Supervisors Pressure Test Supervisors Weld Controller Document Controller Planner Procurement Lead **General briefing of those who where interested (approx. 10%)**	**Stakeholders with feedback** **Detailed briefed for feedback during research** Engineering Lead Innovation Lead Fabrication Lead IT Systems Lead **Interview of a all**

Influence on handover

Interview preparations



Results of interviews



1st research question

Analyze results (previous slide) → **Identify main impact factors** → **Identify Handover content** (next slide)

First Research question:

- What are the main impact factors causing confusion and misinformation in the installation handover format?

Analyze of interviews gave this answer:

- Amount of insignificant information
- Amount of pages in the handover
- Number of revisions

Second Research question:

- How can the new knowledge about the main impact factors contribute to make the handover format more correct, intuitive, and usable for the receiving stakeholders?

Starting tasks:

- Understand the content of the handover
- Understand the usability of the information elements in the handover
- Understand the reasons for revisions

Results of handover content analysis

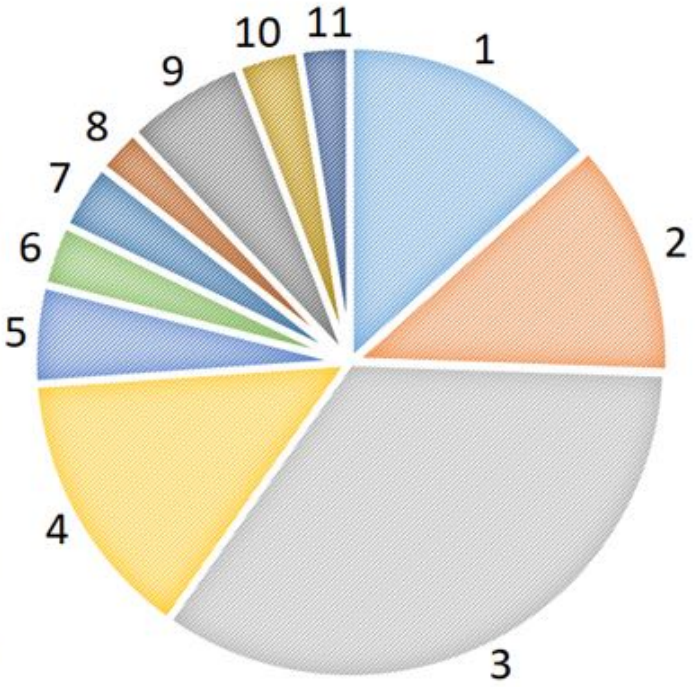
Identify main impact factors (previous slide) → **Identify Handover content** → **Identify Information Elements** (next slide)

Scope:

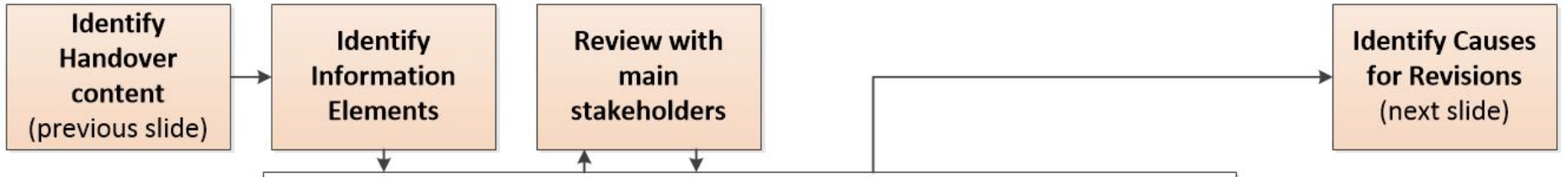
- The largest project over the last eleven years had 196 unique installation handovers with 318 additional revisions
- The total amount of pages for the last revision of the 196 installation handovers are 8,879.
- The total amount of pages including the 318 additional revisions is 28,582.

Content in each category:

Handover Categories	Pages on last revision	In percent
1. FrontPage & Content overview	1 187	14 %
2. Piping ISO drawings	1 082	12 %
3. Pipe Support drawings	3 038	34 %
4. 3D Model pictures	1 254	14 %
5. Welding Procedures	450	5 %
6. Torque & thread seal requirements	284	3 %
7. Piping & Instrument Diagrams	307	4 %
8. Material Take Offs	210	2 %
9. Standard support details	552	6 %
10. Structural and Mechanical Layout	286	3 %
11. Other	229	3 %
Total pages	**8 879**	**100 %**



Information elements usability



Value of information elements:

Content category	The zero measurement for number of information elements	Information elements required in a paper format	Information elements that may be digitized	Information elements that are not required
1. FrontPage & Content overview	17,640	196	16,072	1,372
2. Piping ISO drawings	129,840	83,334	19,476	27,050
3. Pipe Support drawings	133,672	3,038	106,330	24,304
4. 3D Model pictures	10,032	10,032	0	0
5. Welding Procedures	8,100	450	0	7,650
6. Torque & thread seal requirements	24,992	3,408	3,408	18,176
7. Piping & Instrument Diagrams	23,946	23,946	0	0
8. Material Take Offs	6,048	5,640	408	0
9. Standard support details	3,312	3,312	0	0
10. Structural and Mechanical Layout	2,288	2,072	216	0
11. Other	3,378	2,383	900	95
Total amount	**363,248**	**137,791**	**146,810**	**78,647**
Each category in percentage	**100%**	**38%**	**40%**	**22%**

Identification of causes for revisions

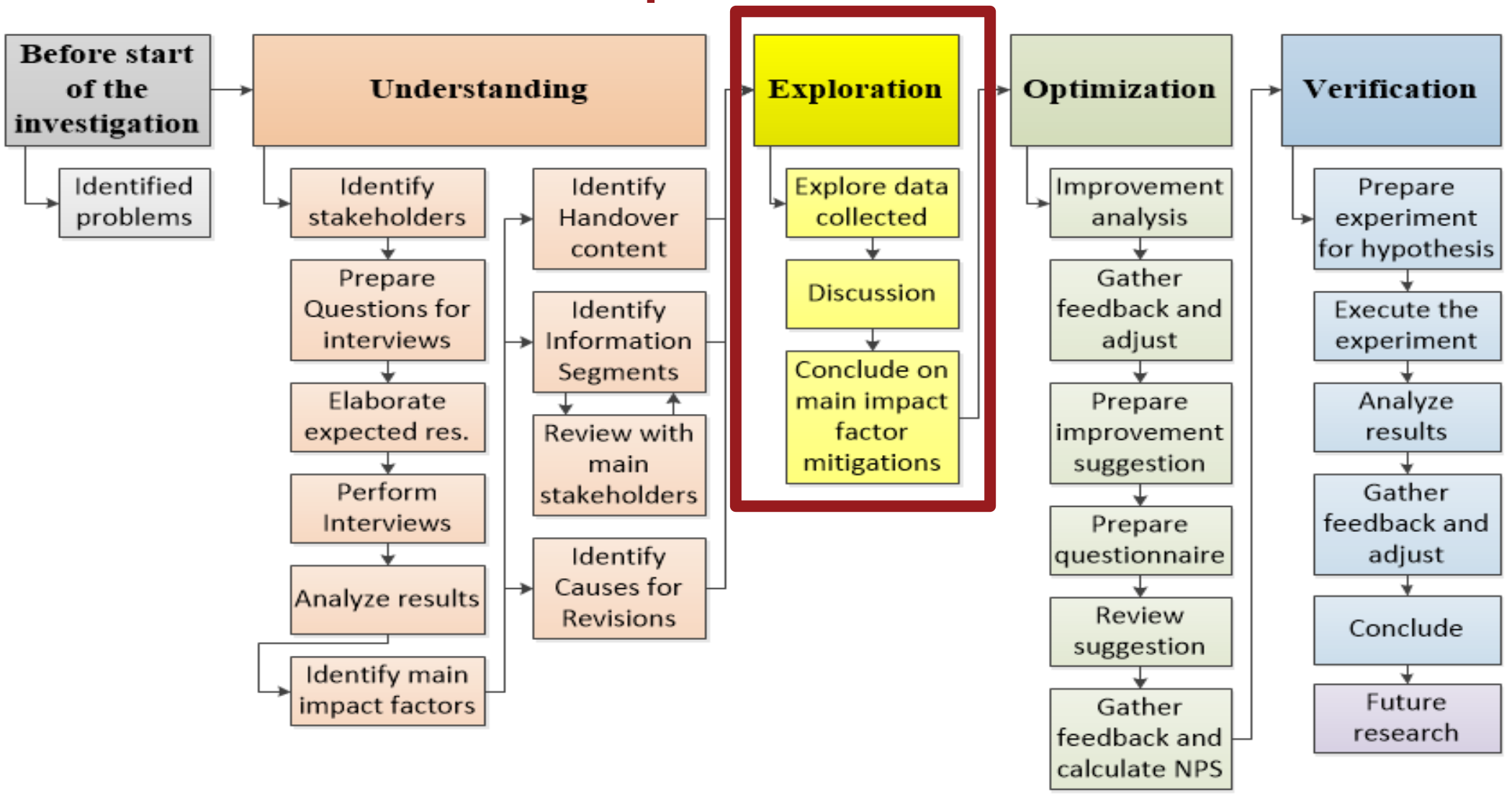
Identify Information Elements (previous slide) → **Identify Causes for Revisions** → **Exploration** (next slide)

Value of information elements:

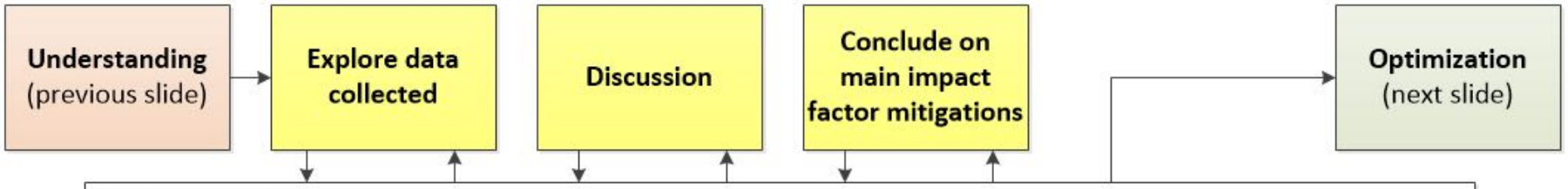
- Results of 100/318 checks at random

Main Cause Priority	Categories	Sample results	Standard deviation
First Priority	Has to be in paper format (External)	16	± 4,0
Second Priority	Has to be in paper format (Internal)	24	± 4,9
Third Priority	May be digitized	27	± 5,2
Fourth Priority	May be avoided	33	± 5,7

Exploration



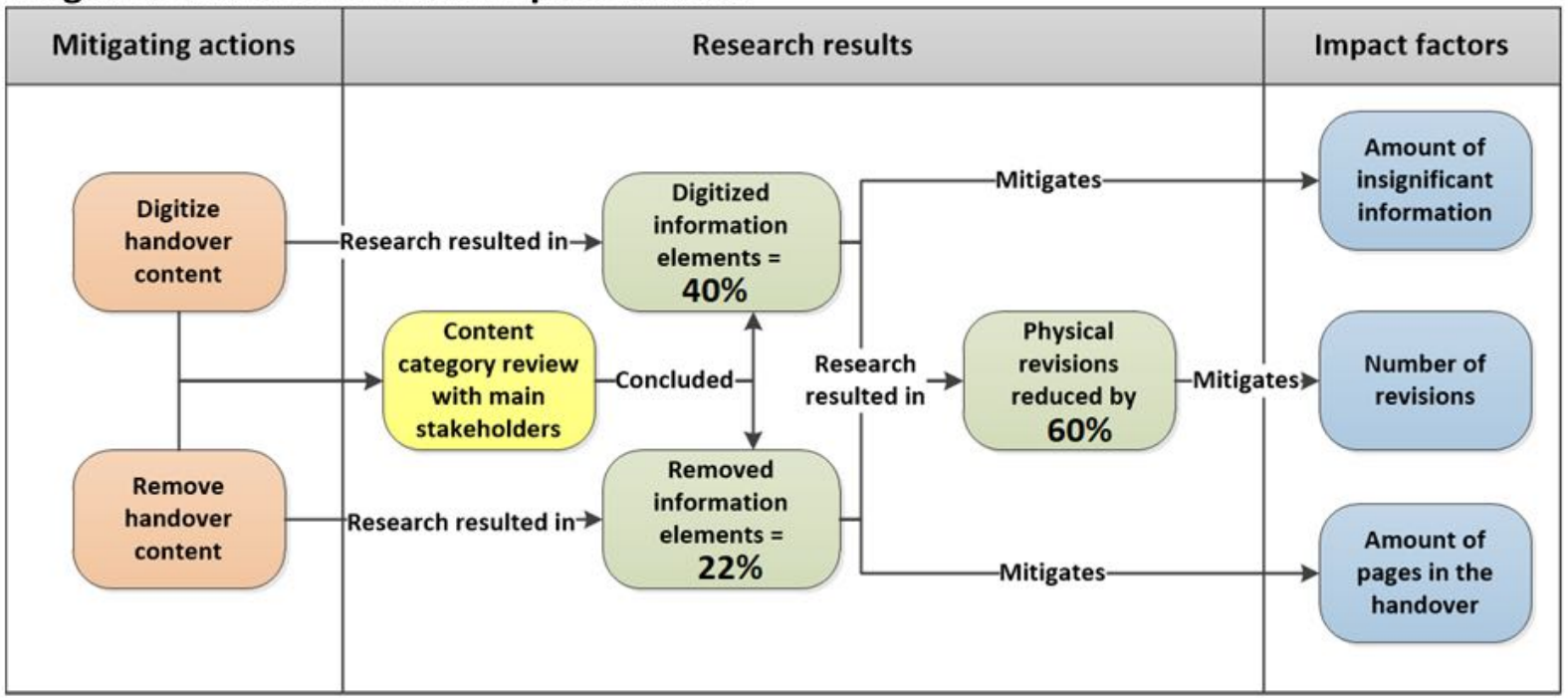
Mitigations to main impact factors



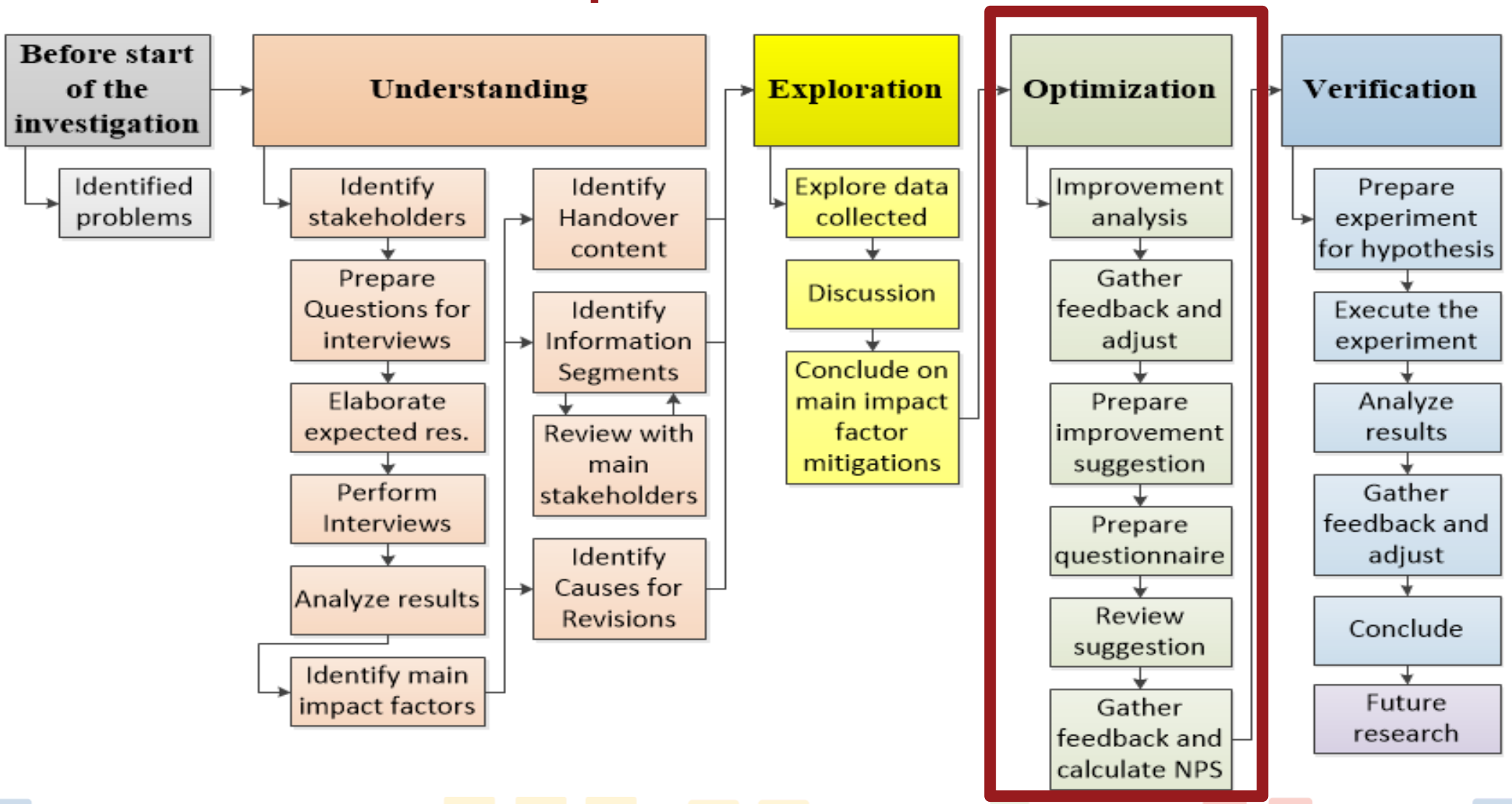
Understanding summary:

- Potential of digitizing 40% of information elements
- Potential of removing 22% of information elements
- Potential of avoiding 60% of revisions

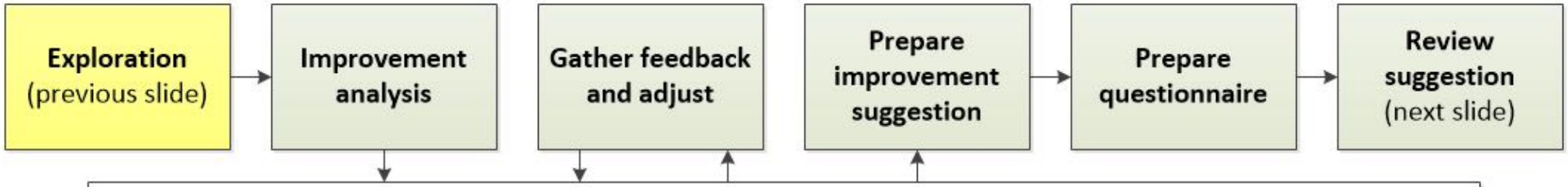
Mitigation actions for main impact factors:



Optimization



Improvement Analysis Results

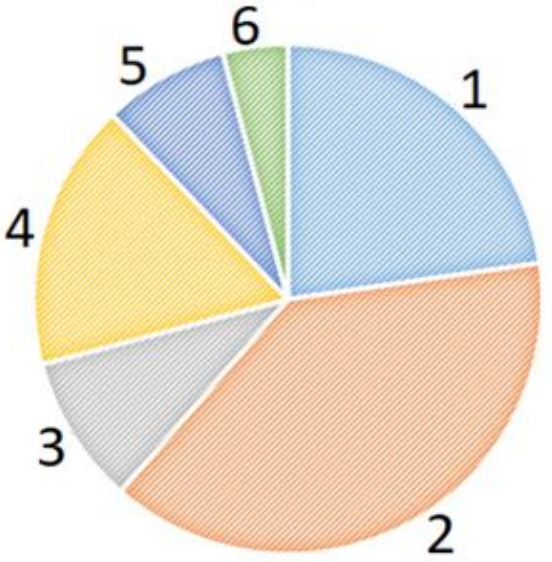


Imprvment estimats:

- Combined 1,187 Piping Isometric data and other data into 737 Installation Isometric
- Potential of reducing overall documents in handovers from 8,879 to 3,242 exculding revisions
- Potential of reducing overall documents in handovers from 28,582 to 7,203 including revisions

Estimated information elements and number of pages in new handover format

Updated Handover Categories	Information elements in first revision	Pages in revi revision	Pages in percent
1. Piping installation ISOs	88 456	737	23 %
2. 3D Model pictures	10 032	1 254	39 %
3. Piping & Instrument Diagrams	23 946	307	9 %
4. Standard support details	3 312	551	17 %
5. Structural Layout Drawings	2 072	259	8 %
6. Other	2 383	134	4 %
Total pages	**130 201**	**3242**	**100 %**



Optimization Slide 1/3

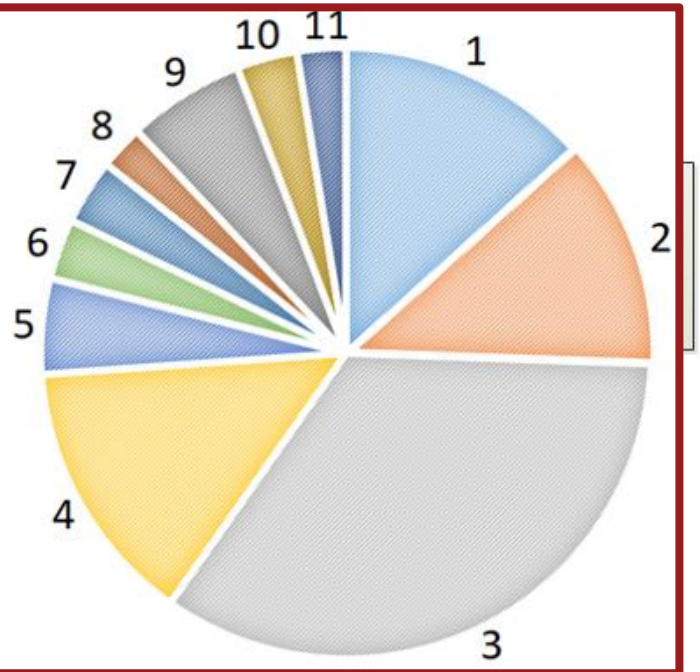
Exploration (previous slide) → **Improver analys**

Imprvment estimats

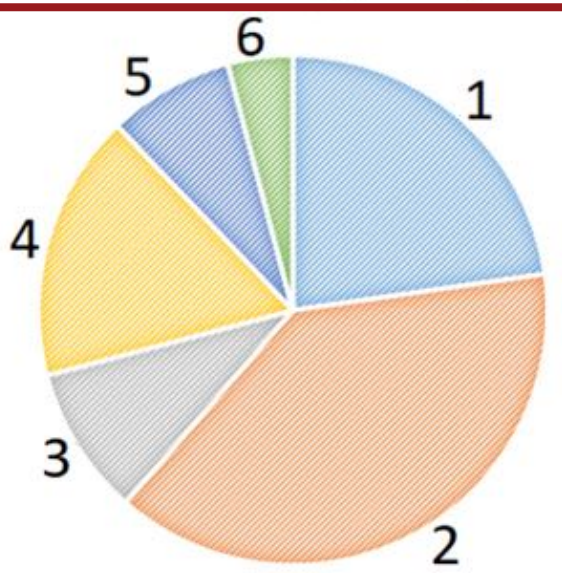
- Combined 1,187 Piping Is
- Potential of reducing over
- Potential of reducing over

Estimated informatic

Handover Categories	Pages on last revision	In percent
1. FrontPage & Content overview	1 187	14 %
2. Piping ISO drawings	1 082	12 %
3. Pipe Support drawings	3 038	34 %
4. 3D Model pictures	1 254	14 %
5. Welding Procedures	450	5 %
6. Torque & thread seal requirements	284	3 %
7. Piping & Instrument Diagrams	307	4 %
8. Material Take Offs	210	2 %
9. Standard support details	552	6 %
10. Structural and Mechanical Layout	286	3 %
11. Other	229	3 %
Total pages	**8 879**	**100 %**

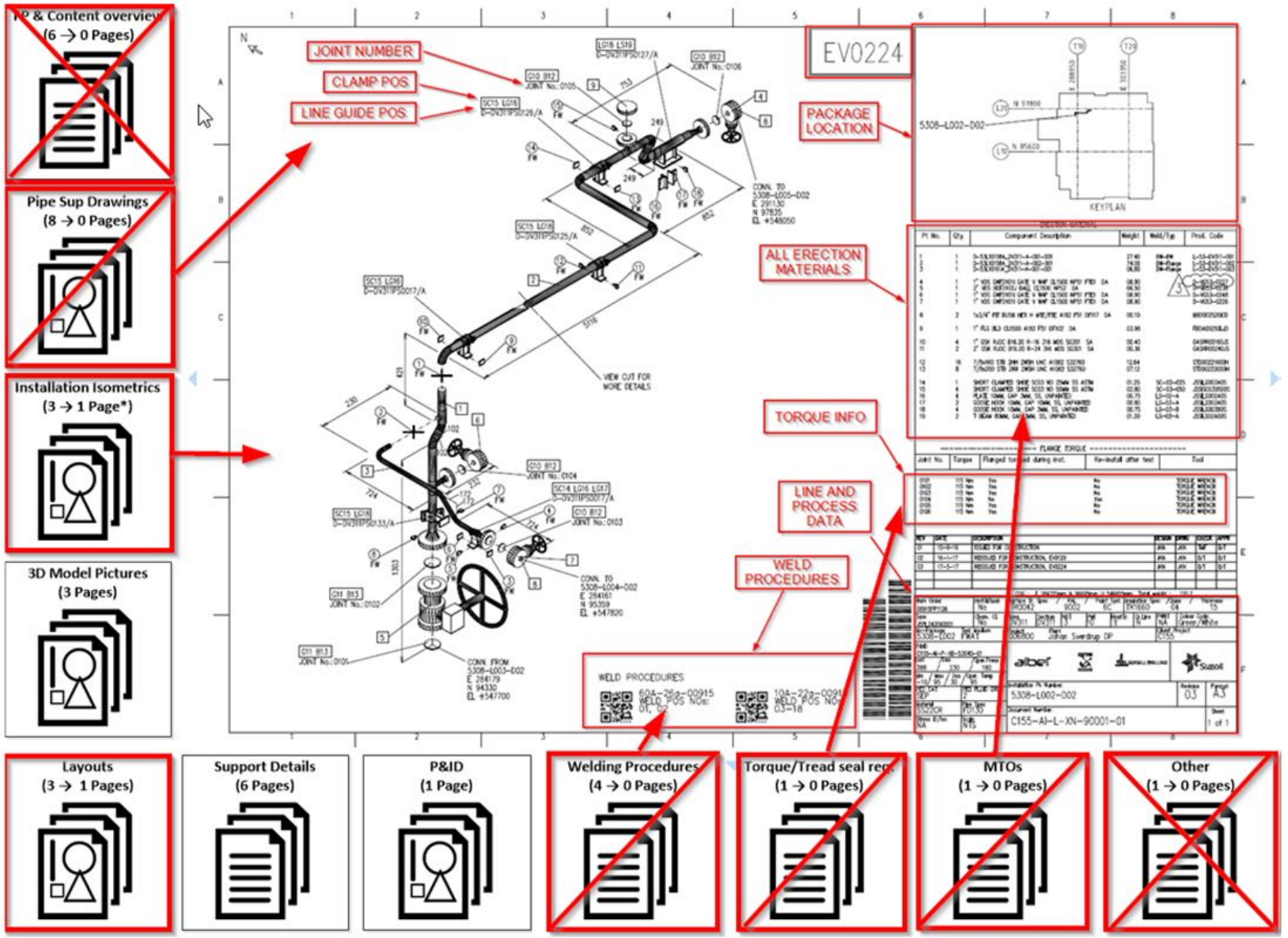


Updated Handover Categories	Information elements in first revision	Pages in revi revision	Pages in percent
1. Piping installation ISOs	88 456	737	23 %
2. 3D Model pictures	10 032	1 254	39 %
3. Piping & Instrument Diagrams	23 946	307	9 %
4. Standard support details	3 312	551	17 %
5. Structural Layout Drawings	2 072	259	8 %
6. Other	2 383	134	4 %
Total pages	**130 201**	**3242**	**100 %**



Optimization
Slide 2/3

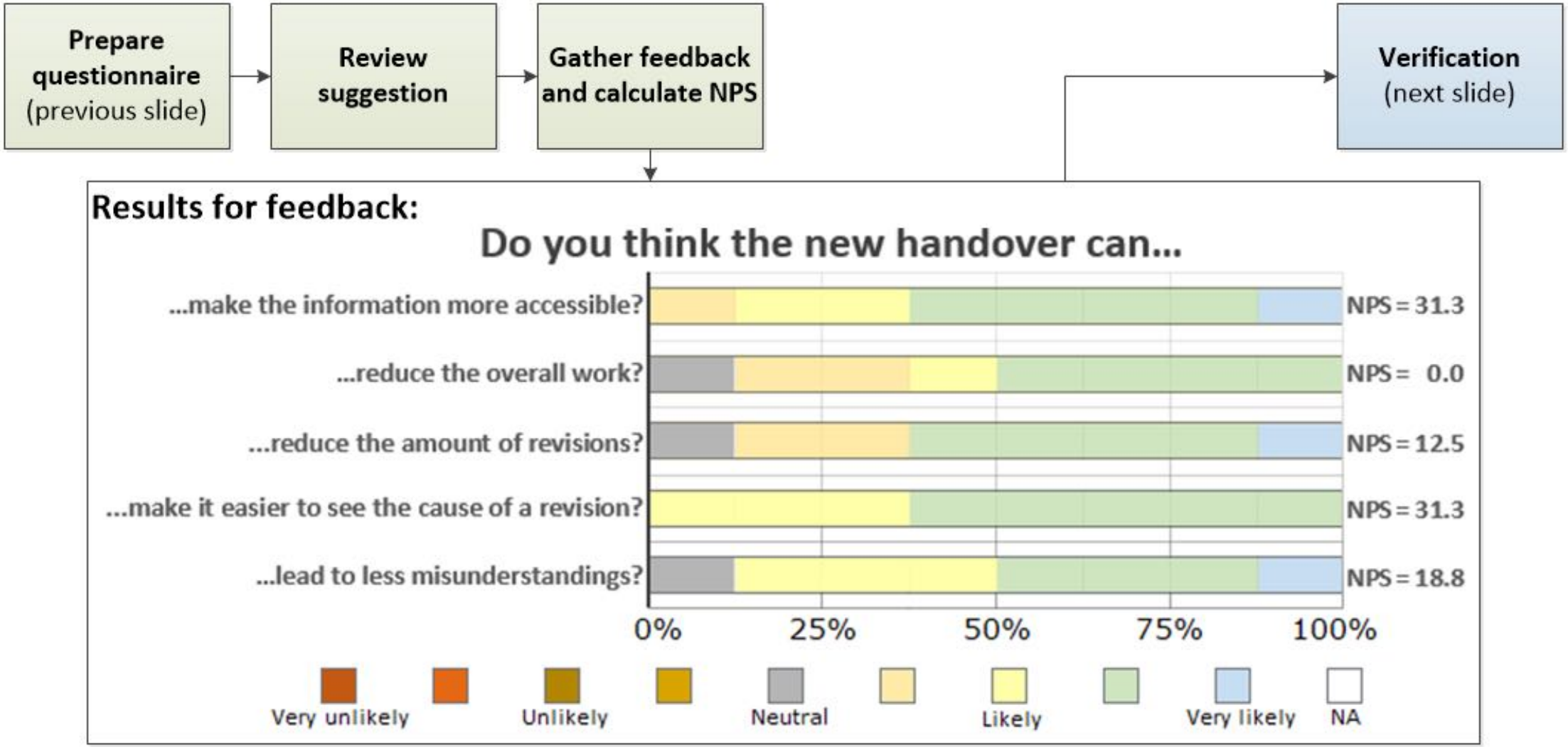
New Installation Handover: Example



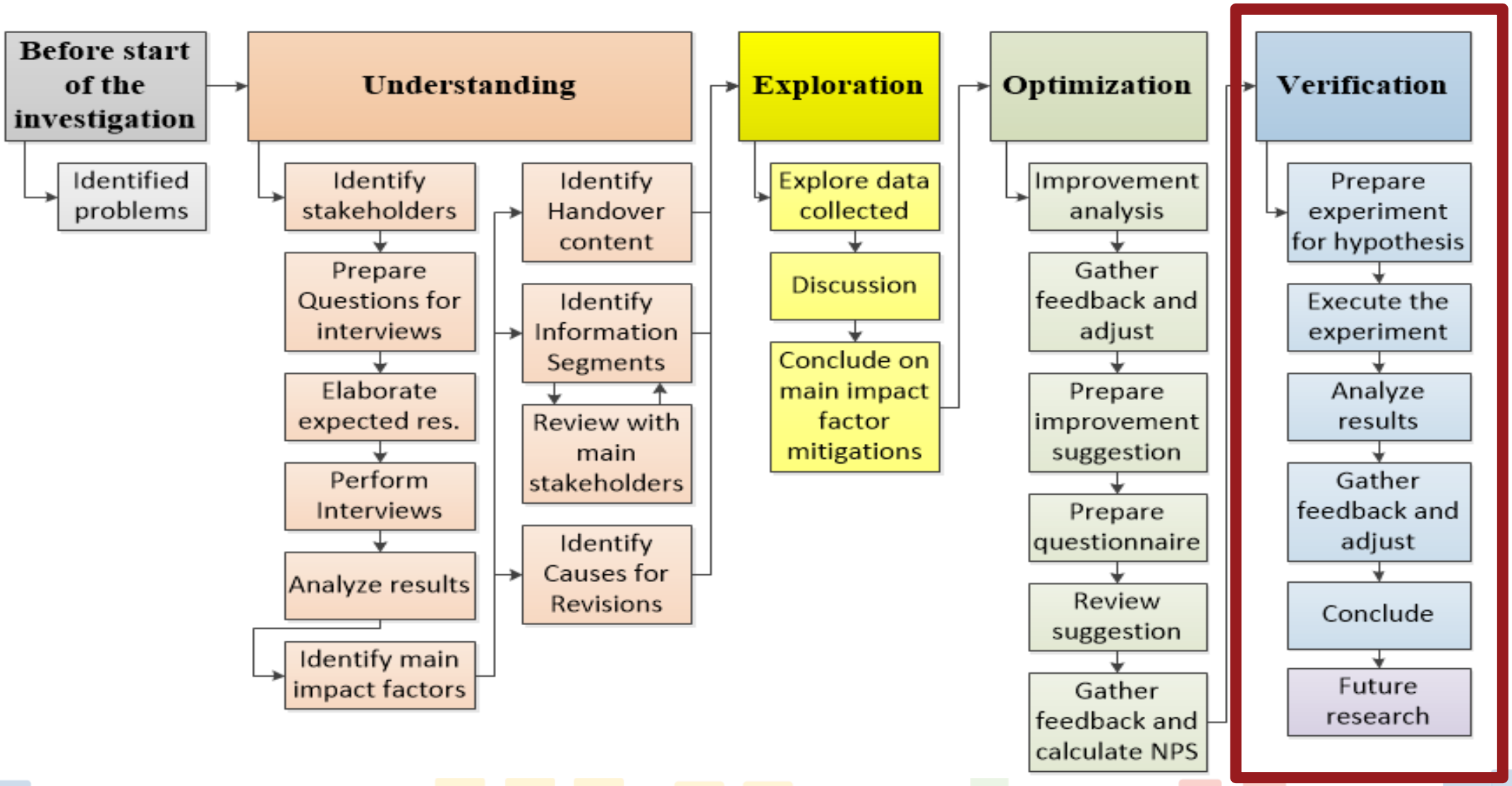
New Installation Handover:

- Contains 1 Installation Isometric
- Consists of a total of 12 pages

Questionnaire Results

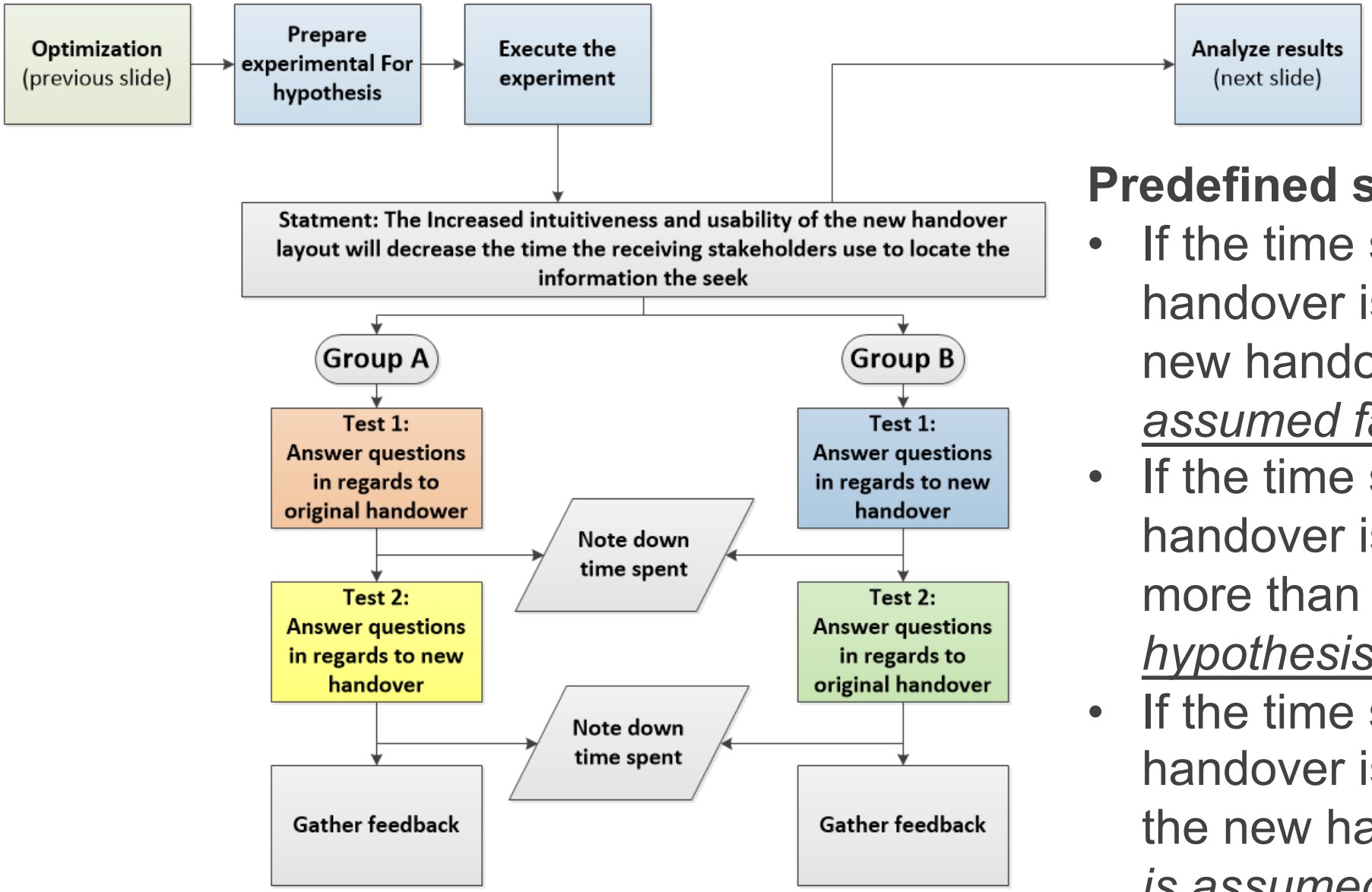


Verification



Verification
Slide 1/2

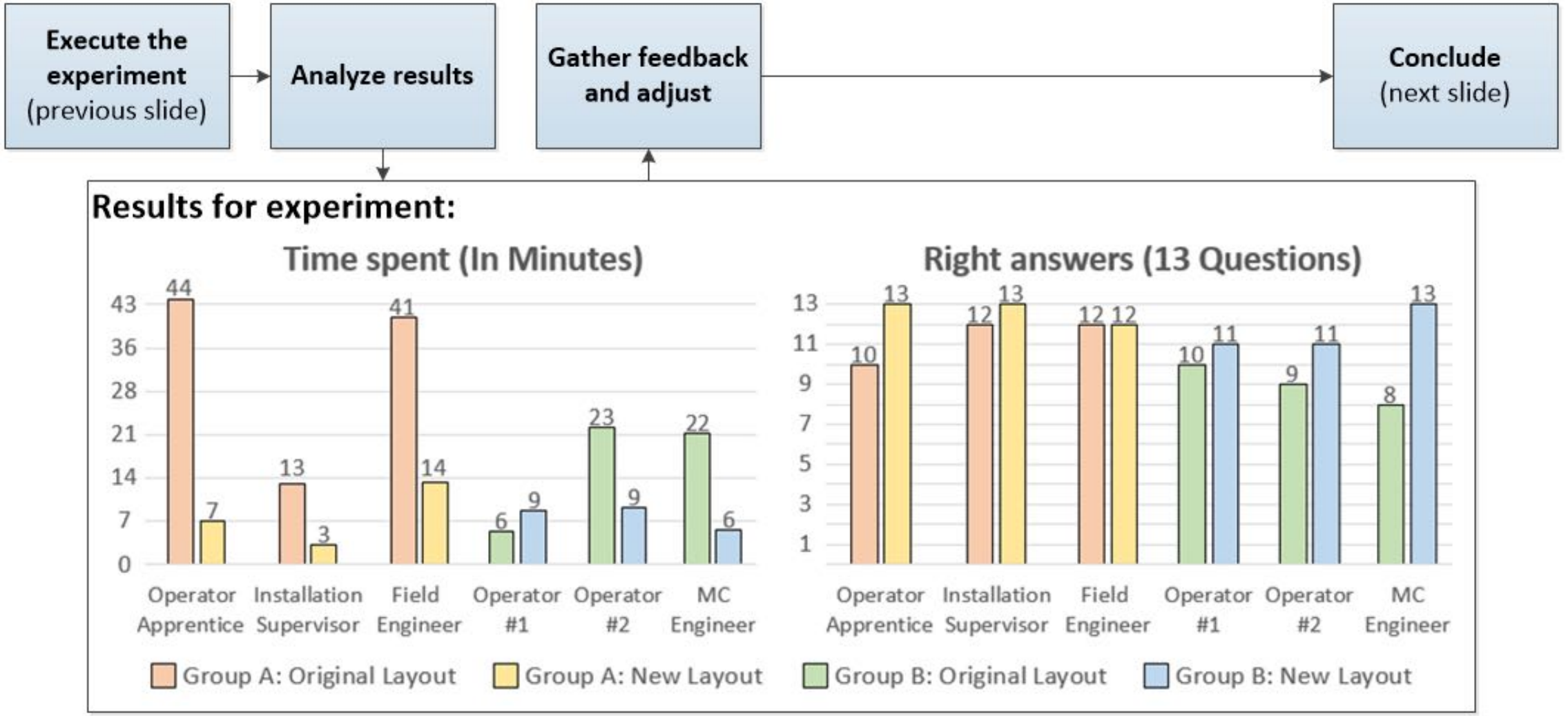
Experiment Method



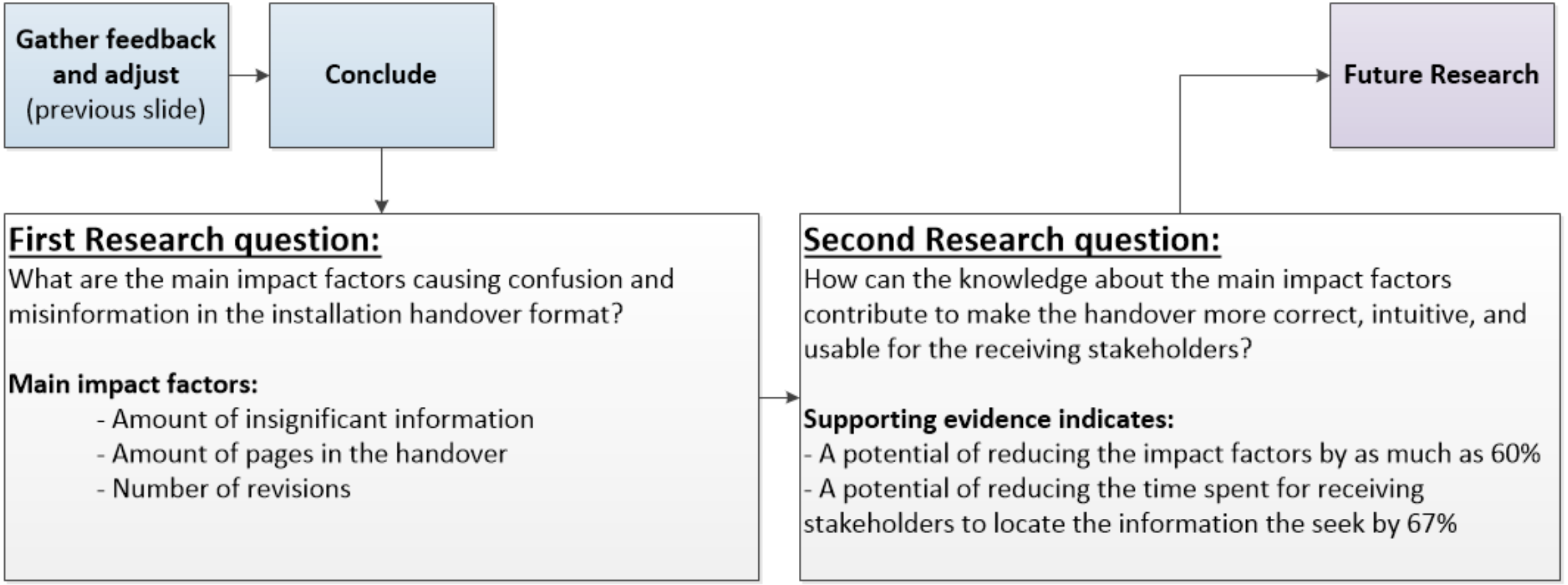
Predefined set of rules:

- If the time spent on the old handover is less or equal than the new handover, *the hypothesis is assumed false*
- If the time spent on the old handover is between 0 and 10% more than the new handover, *the hypothesis is inconclusive*
- If the time spent on the old handover is greater than 10% of the new handover, *the hypothesis is assumed true*

Experiment Results



Conclusion


Gather feedback and adjust (previous slide)
Conclude
Future Research
First Research question:
What are the main impact factors causing confusion and misinformation in the installation handover format?
Main impact factors:
- Amount of insignificant information
- Amount of pages in the handover
- Number of revisions
Second Research question:
How can the knowledge about the main impact factors contribute to make the handover more correct, intuitive, and usable for the receiving stakeholders?
Supporting evidence indicates:
- A potential of reducing the impact factors by as much as 60%
- A potential of reducing the time spent for receiving stakeholders to locate the information the seek by 67%

29th Annual INCOSE international symposium

Orlando, FL, USA

July 20 - 25, 2019

www.incose.org/symp2019